

4-AMINOPYRIDINE BAITS ON BAITING LANES PROTECT SUNFLOWER FIELDS FROM BLACKBIRDS

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ABSTRACT

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4-Aminopyridine baits, applied by hand in 6.6-m swaths from baiting lanes, were evaluated in 1981 for protecting ripening sunflower from blackbird damage in six test fields in North Dakota, U.S.A. Paired experimental untreated units lost 4 902 kg of sunflower seed to birds during the 6-day treatment period whereas baited units lost 2 332 kg of seed or 52% less. However, untreated units also had somewhat more damage during pretreatment periods and therefore, based on ratios of pretreatment losses, observed losses on baited units were only 43.3% less than expected.

Peak numbers of blackbirds damaging individual fields ranged from 5 000 to 31 000 during the test period. The species composition of feeding flocks was estimated to be 73% red-winged blackbirds (*Agelaius phoeniceus*), 20% yellow-headed blackbirds (*Xanthocephalus xanthocephalus*), and 7% common grackles (*Quiscalus quiscula*). The estimated kill of 169 blackbirds was similar in composition. However, 30 of 34 birds seen giving distress displays were yellow-headed blackbirds. We found evidence that many red-wings broke the chopped corn baits before consuming them, thereby lengthening response times and contributing to lower bait effectiveness.

The benefits of baiting were calculated to be only \$1.75 for each \$1 of cost (exclusive of labor). Nevertheless, growers would have saved about \$25 worth of sunflower seed for each hour spent baiting and creating lanes.

INTRODUCTION

Granivorous birds damage ripening sunflower (*Helianthus annuus*) on all continents (Besser, 1978) and North American blackbirds cause several million dollars loss to this crop in a single state (North Dakota) in the United States (Henne et al., 1979). Baiting with a chemical frightening agent, 4-aminopyridine (4-AP), has been the chief control method employed to combat the most serious blackbird damage, with >100 000 ha baited with the registered product, Avitrol® FC Corn Chops-99S (AFCC-99S) in the United States in 1980 (K. Swindle, personal communication, 1980).

In AFCC-99S baits, chopped corn particles are treated with a 3% concentration of 4-AP, blended with 99 parts of untreated particles, and broadcast at the rate of 3.3 kg/ha in swaths covering 1/3 of the field or 1.1 kg/ha of field. A blackbird ingesting a treated particle emits distress cries within 20 min, often while ascending >100 m in a circular, erratic flight. This behavior often clears blackbirds from treated fields with less than 1% of the population directly affected (De Grazio et al., 1972). Flocks thus frightened often move several miles from the field before feeding again (De Grazio et al., 1971, Besser et al., 1978). The greatest share of protection appears to be provided by the prolonged absence of feeding birds in treated fields, as feeding birds serve to decoy other flocks to the field (Besser et al., 1973).

Although AFCC-99S has given satisfactory results in protecting sunflower (Besser, 1975; Besser and Guarino, 1977; Henne, 1978), a number of problems still confront growers attempting to protect their fields with it. Recent cultural practices that use narrower row widths and increased fertilizer rates have resulted in increased canopy foliage that often obscures baits from birds and affected birds from others in the flocks. These practices lower the effectiveness of baits until plant leaves begin to wither (Besser et al., 1979).

Solutions to a few of these problems have been proposed. Besser and Pfeifer (1978) suggested that increased density of bait particles in baited swaths might be a more efficient distribution pattern than broadcasting baits over the currently registered 18-m width of baiting swath, and that unplanted rows or removed rows of plants (baiting lanes) be left at intervals in fields to allow unrestricted passage of a man or a vehicle applying bait, thereby opening up the dense canopy of sunflower and increasing bird access to bait.

The present study, employing reduced swath widths and baiting lanes, was conducted in August and September 1981. A randomized block (split field) experimental design on large fields (>20 ha) was used in an attempt to minimize fluctuations in numbers of feeding birds and differences in susceptibility (palatability) of seeds between fields; two factors that had resulted in large experimental variation in previous tests.

METHODS

Test locations and acreages

Six commercial oil-sunflower fields in Ramsey and Benson counties (near Devils Lake), ND, were used in this study. Fields ranged in size from 20 to 48 ha (Detail on size and location of fields is available from the authors.) Growers whose fields were used in this study were paid for bird damage during the 12-day period of the test and for removal of sunflower plants on baiting lanes.

Experimental design and damage assessment

Fields that had been in bloom <15 days were selected for inclusion in the study from a pool of fields under daily observation. When 500 or more blackbirds were observed feeding in a field, 20 or more (most commonly 60) randomly located 1.35 m² sampling plots were established in the field and the damage on them measured. Damage in these plots was again measured 3 days later. If the field was estimated to have losses >300 000 cm² of surface area of heads to birds during this 3-day period, the field was split into three parts, two experimental units separated by a buffer zone 100 m or more in width. Twenty or more additional random plots were then established in each of the experimental units. Three test fields established in August were sampled by simple random sampling; three test fields established in September were gridded into strata of 100 rows × 100 paces (about 0.7 ha each) and a sample plot established within each stratum on both the initial and the second survey.

Each of the plots was marked with a colored ribbon or flag placed on the heads adjacent to the first and last head in the plot. A transparent template, originated by C.P. Stone and described by Dolbeer (1975) was used to measure the cm² of bird damage on each head. Diameters of sample heads and undeveloped centers were measured on the final survey. To determine seed weights, necessary to convert cm² loss to weight loss, sunflower heads were bagged on ten additional random plots in each test field during the test, and then remeasured, shelled, and weighed near harvest. This also allowed a yield prediction, if needed.

The six selected fields were split parallel to the direction of flightlines arriving from roosts in the morning. In addition, they were split to give experimental units somewhat of a balance of bird numbers; this procedure sometimes resulted in units with unequal acreages. Experimental units were most commonly of approximately equal size, but this was not a treatment necessity. Fields that had more than a fourfold difference in damage between experimental units during the 3-day period preceding treatment choice were to have been rejected, but none had such damage imbalance. After a 6-day pretreatment period, one of the two experimental units was randomly chosen to be treated for a 6-day period. After this period, damage on plots in experimental units was remeasured to determine differences in damage increases. Expected damage (T_2) on the baited unit (if no treatment had been made) was computed from the following equation:

$$T_2 = T_1/U_1 \times U_2$$

where T_2 = expected kg loss on the baited unit, treatment days 1–6; T_1 = kg loss on the baited unit, pretreatment days 1–6; U_1 = kg loss on the unbaited unit, pretreatment days 1–6; U_2 = kg loss on the unbaited unit, treatment days 1–6. The differences between expected and observed damage on the baited unit served as the indicator of damage reduction (protection afforded)

by the baiting. These differences were analyzed by a paired 2-tailed *t*-test.

Treatment of fields

The experimental unit selected for treatment and one-half the adjacent center buffer zone were baited with Avitrol® FC Corn Chops-99S at the rate of 1.1 kg/ha of field. This was accomplished by knocking down plants on a row of sunflower (either manually or with the use of a three-wheeled all-terrain cycle) just before baiting. In two fields, the rows had been removed several weeks after planting. Bait was distributed by hand from these lanes in a 6.6-m swath (eight 76-cm row spaces) centered on the lane. Lanes were 66 rows (50 m) apart, and were connected by creating lanes 15 m from the field perimeter. Connecting lanes were often the outer row (24th) of the turn lane for cultivation and sometimes had many plants missing. About 0.4 kg of bait was used in baiting 0.8 km of lane and about 1/8 of the area of the treated unit received bait (7.4 kg/ha or about 30 baits per m² of treated swath). The treated units were baited on the evening of the 6th day of the test (usually 4–8 h after the final pretreatment survey) to induce maximum fright response in the largest number of blackbirds, which usually arrived shortly after sunrise.

Treated units were rebaited following the accumulation of 1 cm of rain, provided that 1 000 or more feeding blackbirds continued to use a field. In one field (#5) a reapplication of bait was made on several 100-m segments of lane, where more than 90% of the bait had been removed.

Bird observations

The number of blackbirds (by species) entering each experimental unit was counted during a 10-min period daily between sunrise and 10.00 h throughout the study. The peak number of blackbirds using adjacent cover during this period also was estimated. The number of chemically affected birds and flock response to these birds were recorded during the regular observation periods and during any cursory observations of test fields.

Hazards

Searches for chemically killed or affected target and nontarget birds were made on baiting lanes 3 and 6 days after baiting. A search of 5% of randomly selected rows on the baited unit was made at the conclusion of the 12-day study. All searches were conducted after 11.00 h. All other dead or affected birds observed or collected during other field activities were recorded and intact dead birds were necropsied to determine the number of corn particles in the gullet and gizzard.

Bait analysis

The treated particles in the AFCC-99S bait mixture used in this study were treated with Tracerite[®], a compound that fluoresces under black light. This was done to check possible loss of the active ingredient, 4-aminopyridine (4-AP), from the treated bait particles in transit and blending. A 0.4 kg sample was taken from the bait just before it was used in the first field treated on 21 August. Three samples of 10 Tracerite-treated particles were analyzed for 4-AP content.

RESULTS AND DISCUSSION

Efficacy

Untreated units of test fields lost 4 902 kg of sunflower seed to birds during the 6-day treatment periods, whereas AFCC-99S baited units lost 2 332 kg of seed (Table I). Baited units lost 52.4% less seed than unbaited ones during the treatment period. However, the ratio of losses to birds on pairs of experimental units during the 6-day pretreatment periods varied from 1.1 to 3.2 fold, with losses being greater on untreated units in four of six pairs (Table I). Therefore, a comparison of observed losses on treated

TABLE I

Sunflower seed losses \pm SE (kg) to blackbirds in six test fields, Ramsey and Benson counties, ND, 16 August–18 September 1981

Field	Exp. unit	Pretreatment Days	Treatment Days
		1–6	1–6
1	U	362.3 \pm 106.5	531.1 \pm 123.2
	T	423.3 \pm 101.0	85.4 \pm 28.3
2	U	1 988.2 \pm 578.2	1 185.1 \pm 292.8
	T	614.8 \pm 172.0	226.4 \pm 68.2
3	U	372.5 \pm 139.8	622.4 \pm 211.1
	T	165.8 \pm 63.7	233.8 \pm 83.5
4	U	353.2 ^a	689.6 \pm 65.6
	T	255.4 ^a	262.2 \pm 45.2
5	U	326.2 ^a	1 530.3 \pm 229.1
	T	467.7 ^a	1 489.2 \pm 340.8
6	U	172.1 \pm 46.2	343.0 \pm 187.3
	T	89.4 \pm 23.4	34.8 \pm 27.6
Total	U	3 574.5	4 901.6
	T	2 016.4	2 331.8
Mean	U	595.8	817.0 ^b
	T	336.1	388.7 ^b

^aNot calculable, strata not resampled.

^b $P = 0.021$.

TABLE II

Observed and expected loss of sunflower seed (kg) to birds in baited units of six test fields during a 6-day treatment period, Ramsey and Benson Counties, ND, 1981

Field	Observed	Expected	% Damage reduction
1	85.4	620.5	86.2
2	226.4	366.5	38.2
3	233.8	276.9	15.6
4	262.2	476.1	44.9
5	1 489.2	2 194.2	32.1
6	34.8	178.1	80.5
Total	2 331.8	4 112.3	
Mean	388.7 ^a	685.4 ^a	43.3

^a $P = 0.048$.

units during the baited period with expected losses gave a truer indication of the protection afforded by the baiting. Comparison of expected losses vs. observed losses on baited units during the treatment period showed that losses were 43.3% less than expected during the baiting period (Table II). Reduction in expected damage on individual fields ranged from 15.6% (Field #3) to 86.2% (Field #1) (Table II). Three rains, totalling 1.68 cm, that fell on Field #3 during the baited period, thereby leaving the field with ineffectual baits for 2 days, probably contributed heavily to the poor protection afforded that field.

It is noteworthy that four units initially baited between 16 August and 11 September where lanes were established by knocking over plants immediately before baiting, had 53.6% ($P = 0.123$) less seed loss to birds than expected, whereas two units initially baited 12 and 13 September, where lanes had been cleared of plants in July (Fields #5 and #6) had only 35.7% ($P = 0.4$) less seed loss than expected (Table II).

Bird observations

The peak number of blackbirds damaging test fields ranged from 5 000 to 30 550 during the 12-day test period. The peak numbers on untreated units ranged from 3 000 to 22 000, and from 2 300 to 30 000 on treated units (Table III). Peak numbers on baited units during the treatment period were always observed during the first 3 days and usually on the first morning following the initial baiting.

The peak test populations during the 10-min regular observation periods were composed of 73.6% red-winged blackbirds, 19.6% yellow-headed blackbirds, and 6.8% common grackles (Table IV). Red-wings were the most dependable species for visiting, and presumably revisiting, individual fields

TABLE III

Peak blackbird numbers observed on six test sunflower fields in Ramsey and Benson counties, ND, 16 August–18 September, 1981

Field	Untreated		Treated			Ratio observed/expected on the baited unit
	Pre-	Post-	Pre-	Post-	Expected ^a	
1	1 650	3 000	9 000	11 000	16 362	0.67
2	4 950	22 000	5 000	30 000	22 222	1.35
3	4 000	10 000	1 450	7 000	3 625	1.93
4	3 000	3 700	2 300	1 400	2 837	0.49
5	13 900	4 000	500	16 000	144	111.11
6	10 000	11 000	2 000	4 000	2 200	1.82

^aBased on numbers seen on the untreated unit throughout the 12-day test and on the treated during the 6-day pretreatment period.

TABLE IV

Species composition of blackbirds observed on baited units of 6 test fields in Ramsey and Benson counties, ND, 22 August–18 September 1981

Field	Peak no. by species observed			Total
	Redwings	Yellowheads	Grackles	
1	10 975	1 625	15	12 615
2	27 000	4 500	1 500	33 000
3	5 600	1 400	0	7 000
4	933	8	467	1 408
5	8 000	7 500	3 200	18 700
6	3 960	40	0	4 000
Totals	56 468	15 073	5 182	76 723
%	73.6	19.6	6.8	100.0

and with yellow-heads were responsible for nearly all of the damage in August. Grackles appeared on test fields in September and were the least dependable to revisit fields. The departure of migrant grackles in mid-September from the untreated unit and concurrent appearance of adult male yellow-head migrants on the baited unit of one field (#5) that received 63.9% of all observed damage on baited units, also contributed heavily to lower overall protection. Whereas the other five baited units had only 0.5–1.8 times the number of birds expected, Field #5 had 111 times the expected bird numbers on the baited unit during the treated period (Table III).

During about 18 h of observing baited fields, a total of 34 affected birds was recorded. In all observed instances in mornings when birds were frightened from treated units, they moved to fields or tree cover farther from the

roost or returned to marshes regularly used for loafing. In the evening, they invariably joined flightlines returning to roosts.

Of the 34 affected birds seen, 30 (88.2%) were yellow-heads, the other four were red-wings. It was apparent that yellow-heads displayed in distress flights more readily than red-wings, probably because individual yellow-heads took greater quantities of baits than red-wings and appeared to select the larger particles of bait. The baits used in 1981 averaged 26 mg in weight. One necropsied adult male yellow-head had 65 particles of corn in its gullet (25) and gizzard (40). The particles in the gullet were not broken. In contrast, an adult male red-wing necropsied at the same time had only six corn particles in its gizzard (0 in its gullet) and all fragments were less than one-half the size of the original baits, indicating they had been broken before being consumed. Unfortunately we found few dead birds, particularly red-wings, intact to permit necropsy. However, laboratory studies have shown that red-wings frequently break corn particles larger than 16 mg before consuming them (D.J. Cunningham, personal communication, 1982) and we observed many broken particles on the bare lanes in Field #5 where red-wings had fed heavily. Breaking of treated chopped corn baits by red-wings (and failure to consume the discarded portion) may be a major factor in the lowered effectiveness of 4-AP-treated corn baits where pure flocks of red-wings are involved. These findings suggest that 4-AP baits for mixed species of blackbirds should contain some (perhaps half) smaller (13–15 mg) chopped corn particles treated with 6% 4-AP to make them one-bait effective.

Hazards

Searches of the baiting lanes and randomly selected rows in baited areas, when extrapolated to the entire baited area, indicated 169 blackbirds and 24 mourning doves (*Zenaida macroura*) were killed during the test period. The estimated blackbird kill was made up of 105 red-wings (62.1%), 43 yellow-heads (24.4%) and 21 grackles (12.4%). These percentages closely parallel the composition of peak numbers of these species observed in test fields (Table IV). It indicates that red-wings did indeed take corn baits, but did not display in distress flights to the extent that yellow-heads did. A post-test baiting of the untreated unit on Field #4 indicated that grackles accepted baits well and displayed well, as four affected grackles were seen <10 min after a flock of 1 000 entered the field. That no affected grackles were seen while we observed baited units during the test seemed to be a happenstance.

The estimated kill of 24 doves on these six fields indicates that baiting lanes with downed sunflower heads with shattered seed are attractive to doves, and that a noteworthy hazard to this species exists. Doves, as many as 75 in one field, were flushed from baiting lanes on all of the baited units. However, dove kills are more readily visible than blackbird kills because the light coloration of dove feathers contrasts with dark soils and the looseness of the body feathers of doves causes feathers to be scattered over many rows

when consumed by predators. This leads to a probable overestimation of dove kills to blackbird kills. We found five blackbird and no dove kills intact.

4-Aminopyridine (4-AP) content of baits

The three samples of Tracerite-4-AP baits selected from the 1:99 diluted baits were found to contain 1.8, 2.1, and 2.4% 4-AP. The mean of these samples is about 70% of the formulated amount of 3.0%. This should be enough to make most baits 'one-bait effective', if not broken. However, this lowered concentration probably increased the time to 'first distress display', and if baits were broken by birds, it may have lengthened response times to the point that many birds had left the field before becoming affected. The loss in concentration occurred despite special care taken to minimize abrasion by blending treated particles with 99 parts of untreated particles in 5-kg batches for only 15–30 s.

Cost effectiveness

The cost of bait (\$214.60) and loss of sunflower from installing baiting lanes (\$83.05) (exclusive of labor) amounted to \$297.65 on the 84 ha of treated units and the benefits (seed savings) were calculated to be \$520.16. Therefore the cost-benefit ratio was \$1:1.75 (exclusive of labor). Since it required 9.34 h to bait the fields and to install baiting lanes, the net benefits of \$222.51 would have resulted in a payment to growers of \$24.82/h for their labor.

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